Potamocorbula amurensis

Heather Peterson

In January 1996, DWR revised the Decision 1485 benthic monitoring sampling program. Benthic data are now collected at 10 sites in the estuary: C9 Clifton Court; D16 Twitchell Island; D24 Rio Vista; P8 Rough and Ready Island; D28A Old River; D4 Collinsville; D6 Bulls Head Point (near the mothball fleet); D7 Grizzly Bay; D41 Pinole Point and D41A at the mouth of the Petaluma River. Sites D28A, D4, D7, and D41 are remnants of the historical program. The additional sites have broadened the geographic range of the program and dramatically lengthened the list of collected benthic species. Data from D4, D7, D6, D41, and D41A, in particular, have improved our ability to track the population trends of *P. amurensis* or at least have provided enough data to make the clam graphs more interesting.

Data from all current benthic monitoring sites where *P. amurensis* occurs are displayed in Figure 1.

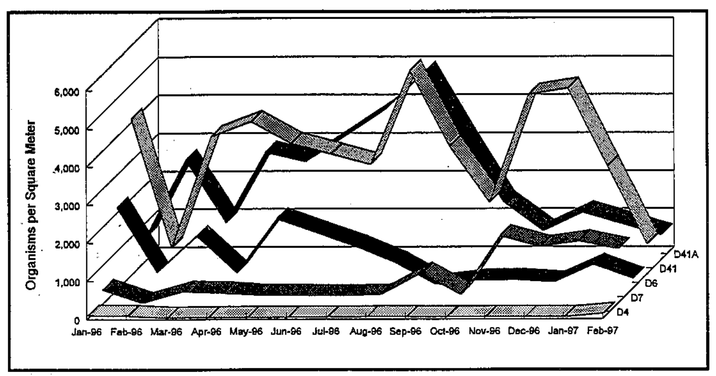

Figure 1
ABUNDANCE OF *POTAMOCORBULA AMURENSIS*, JANUARY 1996 - FEBRUARY 1997

D41A is the westernmost site in our program. As usual, abundance of *P. amurensis* in early spring was low, possibly due to high outflow in late February 1996. Populations grew steadily through the summer, peaking in August at 4900 clams/m^2. *P. amurensis* density declined through fall and winter, reaching 600 clams/m^2 by February 1997.

D41 has generally had the highest abundance of *P. amurensis* of any of the sites sampled. Trends at D41 were similar to those at D41A. Maximum clam density, in August, reached 5300 clams/m^2 at D41. In November and December 1996, while clam density was dropping at D41A, site D41 recovered to 4700-4900 clams/m^2, possibly due to recruitment from late summer spawning.

Clam density at D6 fluctuated between 500 and 2000 clams/m^2 through July, then decreased through fall and winter, with a short rise back to 600 clams/m^2 in January 1997.

Clam density at site D7 seems to show an opposite seasonality to sites farther west. High outflow in February-May 1996 may have kept the water too fresh for many clams to get established in Grizzly Bay before late summer. Populations at D7 peaked at 1700 clams/m^2 in November and remained high through early spring 1997.

Site D4 at Collinsville is the most easterly station where *P. amurensis* is found. We found one or two clams per grab (19-36 clams/m^2) consistently over the past year at this site. Clam abundance at D4 has declined and has remained low level since 1994.

Figures 2, 3, and 4 show population trends in the regions for which we have historical data.

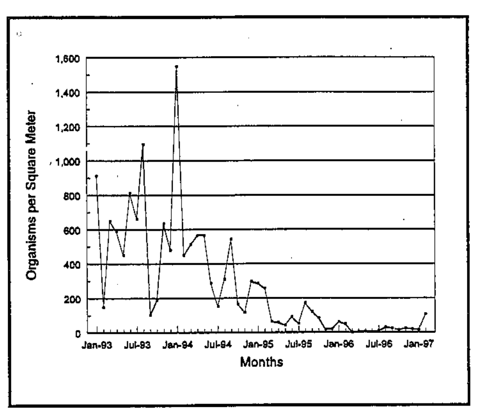

Figure 2
ABUNDANCE OF *POTAMOCORBULA AMURENSIS* AT D4, 1993-1996

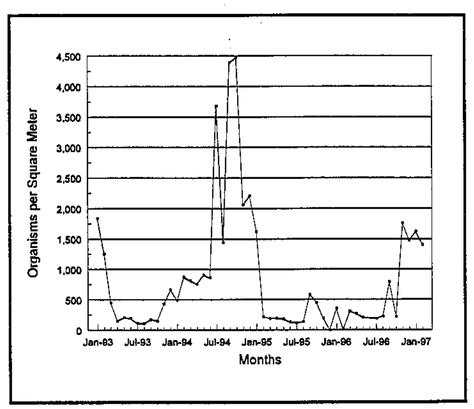

Figure 3
ABUNDANCE OF *POTAMOCORBULA AMURENSIS* AT D7, 1993-1996

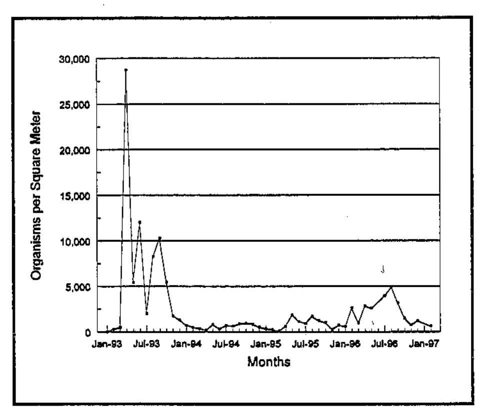

Figure 4
ABUNDANCE OF *POTAMOCORBULA AMURENSIS* AT D41A, 1993-1996

Selenium Trends in North San Francisco Bay

Samuel N. Luoma and Regina Linville, US Geological Survey, Menlo Park

Bioindicators are especially effective in monitoring selenium contamination, one of the most serious contamination problems in San Francisco Bay. The bivalves *Corbicula fluminea*, *Macoma balthica*, and *Mytilus edulis* have all been employed in past studies, either as resident or transplanted species (Risebrough 1977; Johns *et al* 1988). A distinct gradient in selenium contamination, with maximum concentrations near Carquinez Strait, was a feature of North Bay in 1976 in *Mytilus edulis* (Risebrough 1977) and 1985-1986 in *Corbicula fluminea* (Johns *et al* 1988). Selenium concentrations in suspended particulate materials were also highest near Carquinez Strait after the flood of 1986 (Cutter 1989) but were more widespread later in the year, when river inflows were reduced and residence times were longer in San Pablo Bay and Suisun Bay.

Cutter (1989) showed that the most important form of dissolved selenium in the North Bay in 1986-1990 was selenite. Selenite is readily taken up by phytoplankton, biotransformed to organo-selenium, then efficiently transferred to bivalves (clams) that ingest the phytoplankton with suspended particulate material (Luoma *et al* 1992). Bivalves accumulate selenium to concentrations about 10 times higher than the concentration in the phytoplankton. Some of the important resource species in the north bay and delta eat bivalves (sturgeon, diving ducks such as scoter and scaup, dungeness crab). Earlier studies (SWRCB 1991) showed that these predators concentrate the element in their flesh and liver to levels substantially higher than found in the bivalves. Because selenium is a potent reproductive toxin, the well-being of populations of these upper trophic level species is threatened by selenium contamination. The bivalves are good bioindicators of exposure of the resource species.

Resident bivalve communities in the North Bay and Suisun Bay are now dominated by the species *Potamocorbula amurensis*. This animal first became established in North Bay in 1986, and rapidly grew in population abundance, apparently displacing several previous residents. Recent studies, conducted in partnership with the San Francisco Bay Regional Water Quality Control Board, have begun updating understanding of selenium contamination in the bivalves of North Bay. In one phase of that study, selenium concentrations in *P. amurensis* were compared with concentrations observed in past studies in the region around Carquinez Strait. *P. amurensis* was sampled in May 1995, then repeatedly between December 1995 and June 1996 at a station in Carquinez Strait (at USGS station 8.1). The clams were collected from the subtidal zone with a VanVeen grab and 1- or 2-mm sieves. Channel depths were 8-20 meters. From 60 to 120 clams of all sizes were collected at each time and placed into containers of water collected at the site for depuration of undigested gut content. The clams were kept in this ambient water at a constant temperature room at 10°C for 48 hours. Then the clams were separated into size classes of 1-mm difference, and composite samples were constructed from similar-sized individuals. Selenium was determined by Hydride Atomic Absorption Spectrophotometry after digestion in concentrated nitric and perchloric acids at 200°C and reconstitution in hydrochloric acid.

Figure 1 shows the mean concentrations of selenium found in bivalves sampled from resident populations or translocated to the Carquinez Strait area. Studies were conducted in 1975, 1984-1986, and 1996. Selenium was first studied in North Bay in translocated *M. edulis* in 1975. Risebrough *et al* (1977) found a mean concentration of 8 ± 3 μg/g in the transplants near Carquinez Strait (one of the highest concentrations reported). In 1985 and 1986, Johns *et al* (1988) sampled resident *Corbicula amurensis* at near-monthly intervals from a station just landward of Carquinez Strait (the most seaward population of *Corbicula* in Suisun Bay at the time). In 67 samples collected over that period, they found a mean concentration of 6 ± 3 μg/g in the clams. In 1985 and 1996, oysters (*Crassostrea gigas*) were translocated to the Carquinez Strait area to study contaminant bioaccumulation (*eg*, Regional Monitoring Program 1996). Concentrations of selenium in the oysters after 3 months of deployment in summer 1995 was 4 μg/g, similar to the

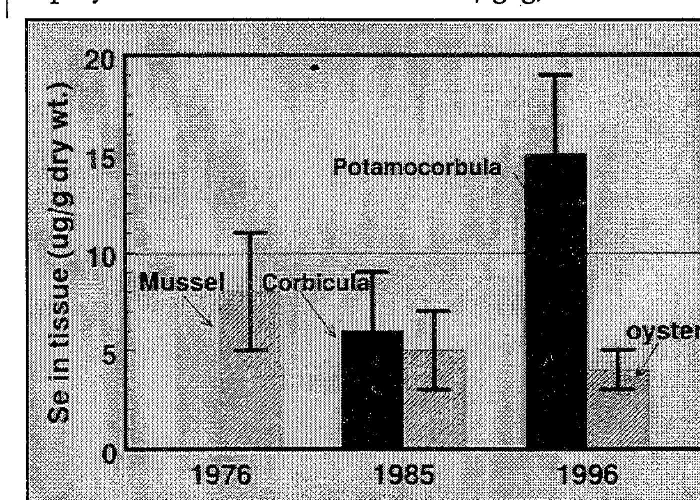

Figure 1
SELENIUM IN BIVALVES, CARQUINEZ STRAIT

concentration observed in this species in a similar translocation experiment in 1985 (5 ± 2 μg/g). In contrast to all earlier studies, and to the oyster transplant study in 1995, mean selenium concentrations in *P. amurensis* in late 1995 and early 1996 were 15 ± 3 μg/g. This is two to three times greater than mean selenium concentrations observed in earlier studies in the same location. The higher concentrations are especially significant in that they substantially exceed values (about 10 μg/g) that convincingly reduce growth or cause reproductive damage when ingested in experiments by birds and fish (Hamilton *et al* 1990; Heinz *et al* 1989). Thus, selenium exposures of birds and fish that depend on bivalves for food have probably dramatically increased since the latter 1980s to levels likely to be of concern to ducks and sturgeon. However, no direct studies of selenium concentrations in the resource species have been conducted since 1990.

A mixture of factors could contribute to the change in selenium exposures in Carquinez Strait. First, *P. amurensis* could be an organism that is more efficient at accumulating selenium than the previous resident species. So the higher selenium concentrations in this clam could be a function of the biology of this exotic species. Studies similar to those conducted by Luoma *et al* (1992) with *Macoma balthica* are needed to determine if bioaccumulation of selenium by *P. amurensis* is unusual. It is also possible that selenium discharges to North Bay increased between the late 1980s and 1995-1996. Potential sources of selenium include refinery inputs and inputs from the San Joaquin River and western Central Valley. Studies of dissolved and particulate selenium concentrations and speciation have been particularly effective in resolving sources of selenium inputs to Suisun Bay (Cutter 1989). Two surveys from 1995-1996 are being analyzed, but ongoing monitoring of these concentrations is probably warranted. A fourth possibility is that residual selenium in the ecosystem, caused by past contamination, is being recycled more intensely than in the past. There is no evidence to support this conjecture, but studies of processes that affect selenium recycling from sediments would be valuable. Whatever the factors that contribute to the elevated concentrations of selenium presently observed in this ecosystem, ongoing monitoring of water concentrations and *P. amurensis* will be necessary to understand the long-term trajectory of these trends and to better understand how the contamination might be affecting upper trophic level organisms.

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Contaminants and Their Potential Effects at the Rivers Confluence and Northern Estuary

Bruce Thompson and Jay Davis, San Francisco Estuary Institute

The San Francisco Estuary Regional Monitoring Program has been monitoring contamination in water, sediments, and transplanted bivalves throughout the lower San Francisco estuary since 1993. Overall, 24 stations are sampled, and numerous trace elements and organic contaminants are measured two or three times annually. This article summarizes some of the results believed to be of particular interest to Interagency *Newsletter* readers. Full reports or datasets are available through SFEI or at our web site (http://www.sfei.org).

Contaminants in Water

In the Regional Monitoring Program, water samples are collected three times each year for analysis of trace element and trace organic contaminants. For some trace elements measured, data from the Regional Monitoring Program can be combined with data generated before the program under the Bay Protection and Toxic Cleanup Program (BPTCP) to form a continuous dataset from 1989 to the present. As an example, mercury data from four RMP stations in the northern estuary (for locations, see Figure 1) are shown in Figure 2. Mercury is typical of many trace elements that associate with sediment particles. Fluctuations in mercury concentrations in estuary water closely follow fluctuations in total suspended solids. TSS concentrations were higher at Grizzly Bay than at the other stations included in Figure 2. Long-term trends for elements like mercury are masked by variation in TSS.

In 1993, the Regional Monitoring Program began monitoring for other elements, such as selenium. Selenium represents a different group of elements that occur primarily in dissolved form in the estuary. Selenium concentrations in the northern estuary showed a different pattern than mercury, with similar concentrations at the four northern estuary stations (Figure 3). The only station that showed a somewhat distinct pattern was the San Joaquin River station.

Regional Monitoring Program water samples are also analyzed for a large number of organic contaminants, including PCBs (polychlorinated biphenyls), organochlorine pesticides, PAHs (polycyclic aromatic hydro-

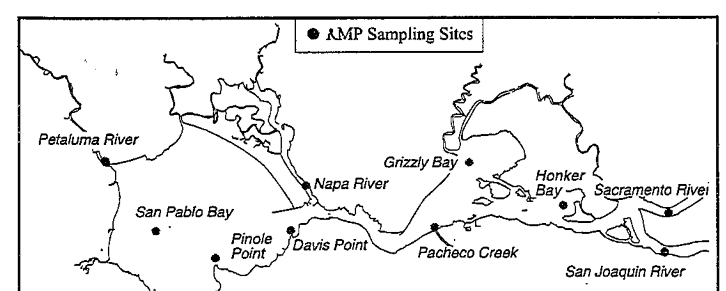

Figure 1
REGIONAL MONITORING PROGRAM SITES IN THE NORTHERN ESTUARY

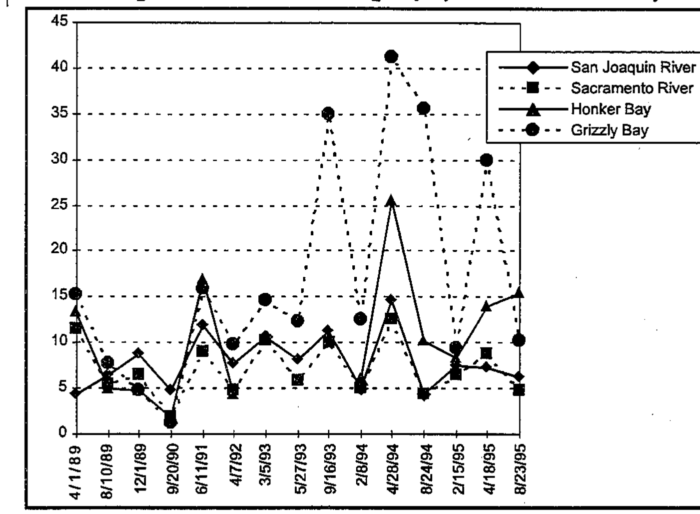

Figure 2
MERCURY CONCENTRATIONS IN NORTHERN ESTUARY WATER
(ng/L)

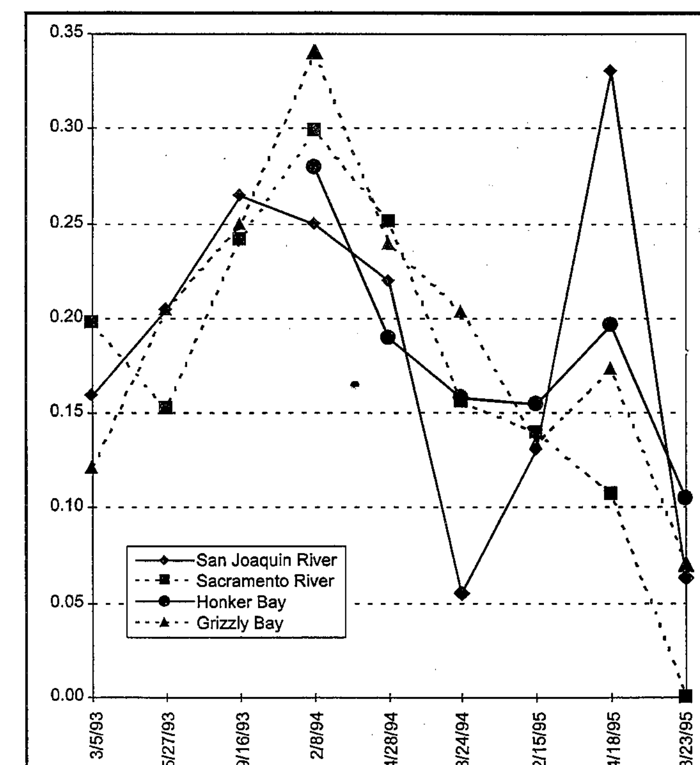

Figure 3
SELENIUM CONCENTRATIONS IN NORTHERN ESTUARY WATER
(ng/L)